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Status of the Neuroendocrine System in Animals Chronically Exposed to Electromagnetic Fields of 5G Mobile Network Base Stations

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We studied the biological effect of chronic exposure to multifrequency electromagnetic fields simulating the effects of 5G NR/IMT-2020 mobile communication systems. Male Wistar rats were exposed to 24-h radiation (250 μW/cm^2) for 4 months. The exploratory activity of the animals and blood concentrations of ACTH and corticosterone were evaluated at the end of each month of exposure and 1 month after exposure. The results suggest that exposure to multifrequency electromagnetic field simulating the effects of 5G systems affected functional activity of the hypothalamus–pituitary–adrenal axis and was stressful in nature.

Key Words: electromagnetic field; neuroendocrine system; adrenocorticotropic hormone; corticosterone; 5G mobile communication systems

Anthropogenic radiofrequency electromagnetic fields (EMF) mainly generated by mobile communications base stations are an essential environmental factor. Many citizens are exposed by multifrequency EMF, a complex mixture of signals of different intensity, and this is the rule rather than the exception [1,2]. The problem of possible general effects of EMF of promising 5G NR/IMT-2020 standard base stations with level exceeding of national hygienic norms on the population has not yet been discussed in our country [3,4].

Single foreign epidemiological studies revealed no adverse effects associated with 5G systems EMF exposure on human health [5,6]. However, it should be accepted that experimental data on biological effects of EMF from 5G communication systems in available literature are more than limited, and the studies are fragmentary and do not cover the whole range of operation standards from units to tens of GHz [7]. All this shows the necessity of experimental study of possible adverse effects of 5G communication systems EMF, especially biological effects of long-term multifrequency exposure, on human health [8].

There are practically no published reports about the biological effect of EMF at ranges and generation modes corresponding to 5G NR/IMT-2020 standards on experimental animals. The latter necessitates experimental studies on animals for evaluation of the biological effects of EMF generated by 5G systems with levels that can be comparable to the possible threshold of adverse effects on humans. From this point of view, it is interesting to study CNS reactions to EMF exposure, which can cause changes in functional activity of the hypothalamic–pituitary system of animals [9-11].

The aim of this study was experimental evaluation of biological effect chronic exposure to EMF simulating the real 5G NR/IMT-2020 mobile communication systems base stations.

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MATERIALS AND METHODS

White male Wistar rats (n=120) weighing 180-200 g at the beginning of the experiment were used in the work. The animals were kept under standard vivarium conditions with controlled environment (6 rats per cage). Water and food were supplied ad libitum, combined light mode (natural/artificial) was 12 h a day. All animals were quarantined and adapted for 14 days prior to the study. Compliance to the requirements for animal handling is confirmed by the conclusion of the Local Ethics Committee of N. F. Izmerov Research Institute of Occupational Health.

The animals were divided into 5 experimental (exposure to EMF of 5G systems, power density (PD) 250 μW/cm^2) and 5 control (sham exposure) groups (12 rats each). Exposure conditions: chronic experiment – exposure for 4 months (120 days; 24-h, 7 days per week) and 1-month (30 days) post exposure period (without irradiation). During exposure period, the animals of experimental groups were kept in radio transparent (plastic) cages. Exposure was carried out by 5G/IMT-2020 base stations with simultaneous use of radio channels with 3.6 GHz (n78 with 100 MHz channel bandwidth), 28 GHz (n257 with 100 MHz channel bandwidth) and 37 GHz (n260 with 400 MHz channel bandwidth) central frequencies. Required exposure conditions were implemented by constant mode of simultaneous maximum load (maximum controlled output power) of 5GNR/IMT-2020 standard mobile communication systems serial base stations in animal placement area. PD level in animal exposure areas was controlled using a Narda SRM-3006 selective electromagnetic field meter (Narda Safety Test Solutions GmbH).

At the end of each month of continuous exposure, the orientation and exploratory activity of animals was recorded, and blood levels of hormones were measured. Animals of the experimental and control groups were decapitated after 1, 2, 3, 4 months of real or sham exposure and 1 month after its ending.

For evaluation of the orientation and exploratory activity in the open-field test, the animal was placed in central sector of the open field and its activity (horizontal, vertical, and hole reflex) and emotional reactions (sniffing and grooming) were recorded. Open Field test hardware-software complex (Otkrytaya Nauka) was used; "entropy" was used as an integral parameter.

Serum concentrations of ACTH and corticosterone were assessed by ELISA using ACTH EIA-3647 and corticosterone ELISA EIA-4164 kits (DRG Instruments GmbH).

The results were statistically processed by the Shapiro–Wilk test, Kruskal–Wallis, and Dunn's test in the R 4.1.2 software environment. The data are presented as Me (Q1-Q3). The differences were significant at p<0.05.

RESULTS

The results of testing during 4 months of EMF exposure and 1 month post exposure revealed a tendency to a decrease (inhibition) orientation and exploratory activity that has an oscillatory character. The maximum decrease close to the significant threshold was observed after 3 months of EMF exposure, whereas 1 month after the end of exposure, this parameter returned to normal. Significant decrease in exploratory activity (hole reflex) in comparison with control group (p<0.05) was revealed only after 2 months of EMF exposure.

The neuroendocrine system of rats responded to chronic 4-month EMF exposure by waveform changes of serum levels of ACTH and corticosterone. ACTH content had a tendency to increase after 3 months of the experiment (Fig. 1).

Changes in serum corticosterone content in exposed animals were more pronounced; significant differences from the control group were revealed after 1 and 2 months of exposure and the maximum increase was found 1 month after end of exposure (Fig. 2).

Chronic exposure induced changes in orientation and exploratory activity and emotional state of experimental animals. These changes were detected starting from 3rd month of exposure, but did not reach significance threshold, and 1 month after the end of irradiation, the excitation and inhibition processes in the CNS returned to normal. Fragmentary peer rewired publications on behavioral reactions of animals exposed to EMF of mobile communication system, including 5G, demonstrate a complex picture with contradictory results [9]. Nevertheless, the dynamics

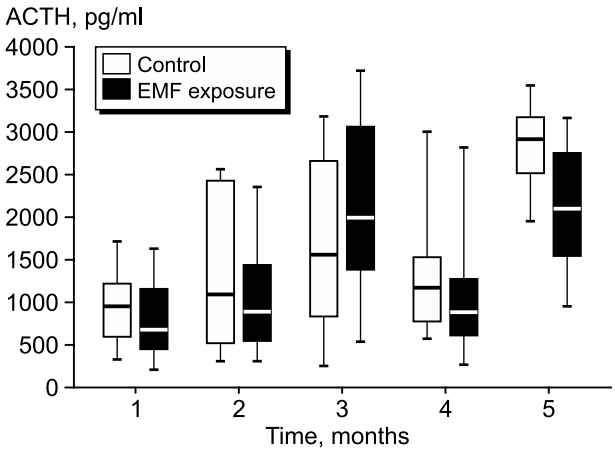

Fig. 1. Dynamics of ACTH content in rat blood serum during chronic 4 months EMF exposure (PD 250 μW/cm^2) and after its termination (5th month).

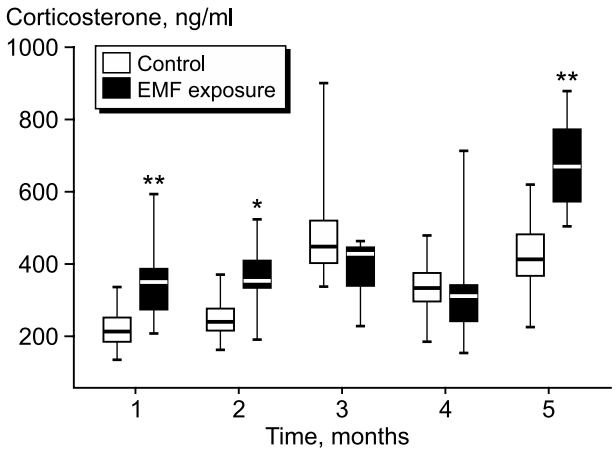

Fig. 2. Dynamics of corticosterone content in rat blood serum during chronic 4 months EMF exposure (PD 250 μW/cm^2) and after its termination (5th month). *p<0.05, **p<0.01 in comparison with the control.

of endocrine markers (hormones of the pituitary and adrenal glands) under the effect of EMF of mobile communication systems are more definite. We revealed distinct reactions of the neuroendocrine system, in particular, the hypothalamic–pituitary–adrenal axis (ACTH and corticosterone levels) [10-12]. Thus, our results suggest that multifrequency EMF exposure of animals led to stressful by nature changes of hypothalamic–pituitary–adrenal axis system function.

The results obtained in the open-field test in combination with neuroendocrine system reactions reflect the certain functional state of animals, that can be considered as moderate stress. These changes, reflecting (judging by the response of the hypothalamic–pituitary–adrenal cortex axis), the stressor impact of EMF, were observed under multifrequency animals EMF irradiation (PD 250 μW/cm^2) during modeling of 5G system influence.

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